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(54) **COMPOSITE STRUCTURAL REINFORCEMENT MEMBER**

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ELEMENT DE RENFORT STRUCTUREL COMPOSITE

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## Description

### TECHNICAL FIELD OF THE INVERTION

[0001] The present invention relates generally to automotive body structural members and, more specifically, relates to reinforcement members for increasing the strength of automotive body structural members.

### BACKGROUND OF THE INVENTION

[0002] In a number of design applications, particularly in the automotive industry, it is essential to provide structural members which are light-weight and yet which have high strength characteristics. A number of exotic metal alloys and the like have been proposed by others in the past for use in forming high strength structural members; however, in some applications, including in the automotive industry, the cost of these alloys is typically prohibitive. Accordingly, there is a need for structural reinforcement members which are light-weight and low-cost and which can be used to compliment existing design structures.

[0003] There is a considerable body of prior art dealing with the reinforcement of motor vehicle structural components. In U.S. Patent No. 4,901,500, entitled "Light-Weight Composite Beam," a reinforcing beam for a vehicle door is disclosed which comprises an open channel-shaped metal member having a longitudinal cavity which is filled with a thermosetting or thermoplastic resin-based material. In U.S. Patent No. 4,908,930 entitled, "Method of Making a Torsion Bar," a hollow torsion bar reinforced with a mixture of resin with filler is described. The tube is cut to length and charged with a resin-based material.

[0004] In U.S. Patent No. 4,751,249, entitled "Reinforcement Insert for a Structural Member and Method of Making and Using the Same," a precast reinforcement insert for structural members is provided which is formed of a plurality of pellets containing a thermosetting resin and a blowing agent. The precast is expanded and cured in place in the structural member. Also, in U. S. Patent No. 4,978,562, entitled, "Composite Tubular Door Beam Reinforced with a Syntactic Foam Core Localized in the Midspan of the Tube," a composite door beam is described which has a resin-based core that occupies not more than one third of the bore of a metal tube.

[0005] In U.S. Patent No. 5,575,526, entitled "Composite Laminate Beam for Automotive Body Construction," a hollow laminate beam characterized by high stiffness-to-mass ratio and having an outer portion which is separated from an inner tube by a thin layer of structural foam is described.

[0006] WO 93/05103 describes a reinforced structural member according to the preamble of claim 1 having a structural member defining a space and a reinforcing member disposed in the space. The reinforcing member has a carrier portion and a thermally expanded portion. The carrier portion is a carrier for the thermally expanded portion, and the thermally expanded portion is bonded to the structural member and the carrier portion. To retain the reinforcing member in the structural member, a bracket welded to the inside of the structural member is provided.

[0007] Although in some applications, there are advantages to these prior art reinforcement techniques, there is a need to provide a reinforcement for rail sections which significantly increases the strength of the rail, particularly at stress points, in a manner which is not only low-cost, but also which adapts readily to mass production assembly.

[0008] In addition, it is known that cyanoguanidine is a commonly-used latent curing agent for foamed epoxy polymers. The most frequently used material has a nominal particle size of about 80 microns. For higher reactivity, micronized versions are sometimes used, e.g. 90% of particles less than 30 microns. In the prior art, conventional usage of curing agents may cause "burning" of the foamed polymer. This is because the heat from the exothermal curing reaction does not readily dissipate. This solution is, however, not practical when the temperature of the oven is pre-set for other conditions, i.e., paint curing the like.

### SUMMARY OF THE INVENTION

[0009] In one aspect, the present invention provides a reinforced structural member according to claim 1. The reinforced structural member has a longitudinal cavity in which a reinforcement member is disposed. The reinforcement member includes a slot through which a pin or other engagement means extends. The pin is secured to opposed sidewalls of the structural member. The sides of the reinforcement member are open and the interior of the reinforcement member is filled with a resin-based material. The reinforced structural member is assembled by securing the pin in position and then dropping the reinforcement member which is filled with resin-based material over the pin. The open sides of the reinforcement member and the resin-based material therein are adjacent sidewalls of the structural member, with the pin passing through the open slot of the reinforcement member. The structural member, which may comprise a motor vehicle rail, moves through a primer oven whereupon the resin-based material expands and adheres to the sidewalls of the structural member to form a strong bond with the inner walls of the structural member. The expanded resin-based material effectively creates a single unitary structure comprising the reinforcement member, the expanded resin and the structural member.

[0010] In another aspect, openings in the reinforcement member adjacent the bottom of the structural member allow resin to expand through the openings and bond to still another surface of the structural member to

provide even greater bonding of the reinforcement member to the structural member.

**[0011]** In still another aspect, the present invention provides a novel epoxy-based reinforcement material*) which contains epoxy resin, an elastomer, a filler, fumed silica, high strength glass spheres, along with curing agent, an accelerator and a blowing agent.

**[0012]** In the present invention, the overall strength of the structural member is significantly increased, reducing cracks at stress points where the reinforcement member is positioned.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0013]**

Figure 1 is a perspective view of a portion of a rail member reinforced in accordance with the present invention.

Figure 2 is a side elevational view of the rail member of Figure 1 partially broken away to illustrate the placement of the reinforcement member and transverse pin.

Figure 3 is a perspective view of the structural reinforcement carrier member before insertion into the hollow structural member of Figures 1 and 2.

Figure 4 is a cross-section along lines 4-4 of Figure 3.

Figure 5 is a perspective view of the hollow structural member with transverse reinforcement pin prior to insertion of the reinforcement member.

Figure 6 is a side elevational view of a hollow frame section partially broken away and reinforced in accordance with the present invention in another embodiment.

Figure 7 is a cross-section of the reinforcement member of Figure 6 along lines 7-7.

Figure 8 is a perspective view of the reinforcement member of Figure 3 without the resin-based core.

Figure 9 is an elevational view of a reinforcement member in another configuration for use in the present invention.

Figure 10 is an elevational view of a reinforcement member and retaining pin in another configuration for use in the present invention.

Figure 11 is a plan view of the structure shown in Figure 1, but with the resin-based core removed.

Figure 12 is an elevational view of a reinforcement member in another configuration for use in the present invention.

*) for the disclosed reinforced structural member according to the invention

## DETAILED DESCRIPTION OF THE PREFEREED EMBODIMENTS

**[0014]** Referring now to Figure 1 of the drawings, reinforced structure 18 is seen having hollow structural member 20 with top or closure plate 22 (shown in phantom). Structural member 20 has opposed sidewalls 24 and 26 and floor or bottom surface 28 and is thus in the nature of a channel-shaped member. Rod or pin 30 extends between opposed sidewalls 24 and 26 as best shown in Figure 5 of the drawings. Pin 30 serves as a shock absorber attachment and as a retaining member for reinforcement member 32. Reinforcement member 32 is disposed within longitudinal channel or cavity 34 of hollow structural member 20 and has a carrier portion 33 (best shown in Figure 8) which serves as a carrier or container for resin-based reinforcement/bonding material 36. In Figure 2 of the drawings, sidewall 24 is shown partially broken away to reveal reinforcement member 32 and the end of pin 30.

**[0015]** Hollow structural member 20 is preferably formed of metal, for example steel, and is most preferably a rail of a motor vehicle. Accordingly, in the most preferred embodiment, reinforced structural member 18 is an automotive beam or rail.

**[0016]** Referring now to Figures 3, 4 and 8 of the drawings, carrier 33 has external sidewalls 38 and 48, internal sidewalls 42 and 44, lower walls 46 and 48 and a connecting wall 50 such that two channel-shaped cavities or reservoirs 52 and 54 are defined. As best shown in Figures 4 and 8, these walls define a c-shaped resin receiving cavity 56. In this fashion, resin-based reinforcement/bonding material 36 forms a c-shaped resin body structure or core 58.

**[0017]** It is to be understood that a number of geometries may be suitable for use as carrier 33 and that the w-design or configuration, while preferred, is only one such configuration. For example a corrugated configuration 70 as shown in Figure 9 or an inverted u-shaped structure 72 as shown in Figure 10 having an external coating of resin-based material (i.e. no external sidewalls) may be suitable in a given application. Also, it may be suitable to completely eliminate carrier 33 and utilize a free-standing resin body 74 as shown in Figure 12. It is generally sufficient that reinforcement member 32 have means for containing or supporting a resin-based reinforcing body and means for interfacing with a position-locating retention means such as pin 30. Most preferably, carrier 33 will define one or more containment sites or reservoirs for the resin-based reinforcing/bonding material while still having openings such that the resin-based reinforcement/bonding material may

expand and bond with sidewalls 24 and 26 of hollow structural member 20.

**[0018]** The gauge or thickness of carrier 33 may vary, but is typically between .025 and about .060. The dimensions of reinforcement member 32 should closely match channel 34 so that there are at least some points of contact between carrier 33 and sidewalls 24 and 26, but should not require that channel 34 be expanded for insertion of reinforcement member 32 during assembly. Pin 30 is preferably metal and, as stated, serves to retain reinforcement member 32 in place by engagement with slot 60 defined by internal sidewalls 42, 44 and connecting wall 50 of carrier 33. It is most preferred that any clearance between pin 30 and slot 60 be sufficiently small such that reinforcement member 32 does not move significantly even prior to expansion of resin-based reinforcement/bonding material 36. The composition of resin-based reinforcement/bonding material 36 as well as the method of assembly of reinforced structural member 18 will be described more fully below.

**[0019]** In still another embodiment of the present invention, referring now to Figures 6 and 7 of the drawings, reinforcement member 32' is shown having a plurality of openings or channels 62 through which resin-based material 36' flows during expansion in the assembly process. This forms additional bonding regions 64 on floor surface 28' of hollow structural member 20. By providing openings 62 in this manner, additional bonding and reinforcing strength is obtained for reinforced structure 18. In this embodiment, all other features of reinforced structural member 18 are identical to those described in connection with the embodiment shown in Figures 1 through 5.

**[0020]** A number of materials may be suitable for use in forming resin-based reinforcement/bonding material 36. Suitable materials should have sufficient body when uncured or partially cured so that the material does not significantly flow out of carrier 33 once formed and prior to inserting in channel 34. Thus, it will be appreciated that carrier 33 receives resin-based reinforcement/bonding material 36 in a preparatory step to form a unit which is subsequently dropped into channel 34. In addition to having sufficient body, it is important that resin-based reinforcement/bonding material 36 permanently expand to contact sidewalls 24 and 26 (and floor surface 28 in the embodiment shown in Figures 6 and Figure 7) and this permanent expansion provides the desired compressive strength. It is also important that resin-based reinforcement/bonding material 36 adhere strongly to the inner surfaces of carrier 33 as well as to sidewalls 24 and 26. Resin-based reinforcement/bonding material 36 must also be sufficiently thermally stable such that it does not degrade at the temperatures experienced in paint curing ovens and the like. Resin-based reinforcement/bonding material 36 should also be light-weight and low-cost and, in general, should impart excellent mechanical strength to reinforced structural member 18.

**[0021]** More specifically, resin-based reinforcement/bonding material 36 should have a density of from about 35 pounds per cubic feet to about 65 pounds per cubic feet prior to being fully cured and from about 25 pounds per cubic feet to 45 pounds per cubic feet once fully expanded in place. The compressive strength of resin body 58 (after expansion and curing) should be at least 1,000 pounds per square inch and more preferably about 1,500 pounds per square inch or greater. The bond between resin body 58 and sidewalls 24 and 26, where sidewalls 24 and 26 are steel, should be sufficient to maintain the intensity of the metal/cure bond. This minimizes separation of resin body 58 from sidewalls 24 and 26 as well as from carrier 33. Cured resin body 58 should be able to withstand temperatures in excess of 450°F for short times absent any significant applied stress and temperatures up to about 175°F for extended periods without exhibiting substantial heat induced distortion or segregation.

**[0022]** Resin body 58 may be formed in place in carrier 33 by closing the open sidewalls 39 and 41 of carrier 33 and injecting or pouring a liquid or paste like resin-based material therein. Material 36 may then be hardened in place by curing or cooling. Alternatively, resin body 58 may be preformed and then inserted into resin receiving cavity 56 which is defined by carrier 33.

**[0023]** One preferred material for use as resin-based reinforcement/bonding material 36 includes a synthetic resin, an expandable self-foaming agent, and a filler. All percentages herein are by weight unless otherwise indicated. In one embodiment, synthetic resin comprises from about 45% to about 70% by weight, and preferably from about 50% to about 60% by weight of resin body 58. A cellular structure is most preferred since it provides a low density, high strength material which is strong and yet light-weight. The self-foaming agent may comprise a chemical blowing agent such as azodicarbonamide or P, P'-oxybis (benzene sulfonyl hydrazide) which comprises from about 0.1% to about 10% and more preferably from about .5% to about 2% by weight of resin body 58. In addition, in some applications it may be preferable to use plastic microspheres which may be either thermosetting or thermoplastic and which are in their unexpanded state until reinforced structural member is heated to expand material 36. It is to be understood that material 36 is not fully expanded until after reinforcement 32 is in position in channel 34. Where blowing agents are utilized as a self-foaming agent, they comprise from about 0% to about 10% and more preferably from about 1.5% to about 3% by weight of resin body 58. A number of fillers are suitable, including glass or plastic microspheres, fumed silica, calcium carbonate, milled glass fiber and chopped glass strand. A filler comprises from about 20% to about 50% by weight and more preferably from about 25% to about 40% by weight of resin body 58.

**[0024]** Preferred synthetic resins for use in the present invention include thermosets such as one-part

epoxy resins, vinyl ester resins, thermoset polyester resins, and urethane resins. The average molecular weight (number average) of the resin component is from about 1,000 to about 5,000,000. Where the resin component of the material 36 is a thermosetting resin, various accelerators such as modified ureas and borontrichloride are included. A curing agent such as dicyandiamide is used to cure the resin. A functional amount of accelerator is typically from about .1% to about 5% of the resin weight with a corresponding reduction in one of the three components, resin, self-foaming agent or filler. Some thermoplastics may also be suitable.

**[0025]** A most preferred composition for use as material 36, and one which comprises another aspect of the present invention, is an uncured one-part epoxy system which is provided in the form of a high-viscosity "dough" that is placed in carrier 33 as described above. With the preferred one-part epoxy dough, the uncured material 36 and thus, reinforcement member 32 can be washed, phosphated or otherwise treated with alkaline or acidic solution without noticeable deterioration of material 36. Thus, material 36 in this embodiment is resistant to acids and bases in its uncured state. Particularly in automobile applications, this feature allows reinforcement member 32 to be inserted at an early stage in the production line.

**[0026]** Accordingly, in one preferred embodiment, material 36 contains in weight percent, from about 30% to 70% epoxy resin, from about 0% to 20% elastomers such as polybutyl rubber, acrylonitrile-butadiene rubber (ABR) or polyisoprene, from about 1% to 30% filler such as calcium carbonate, fumed silica, high strength glass microspheres and from about 0% to 10% blowing agent such as azodicarbonamide or P, P'-oxybis (benzene sulfonyl hydrazide).

**[0027]** In addition, material 36 further includes from about 2% to 10% curing agent such as dicyandiamide or cyanoguanidine. It has been discovered that the size of the particulate curing agent is an important feature of the preferred formulation of material 36. By providing a powdered or particulate curing agent wherein 40% of the particles are greater than 15 microns in diameter, which is fully blended with the other constituents of material 36, even curing with no thermal degradation may be obtained at the temperatures experienced in automotive priming ovens. In other words, by utilizing a one-part epoxy resin containing blends of cyanoguanidine which have a high coarse particle content, no "burning" or reduced levels of "burning" of the interior of the cured epoxy foam mass.

**[0028]** From about 0% to 5% accelerator, such as modified ureas or borontrichloride is also preferably included in material 36. From about 0% to 10% carbon black may also be included.

**[0029]** In the most preferred embodiment, material 36 includes from about 1% to 6% hydrophobic silica and from about 18 to 27 high strength glass spheres which range from about 20 microns to about 400 microns in diameter. The high strength spheres should have a hardness (crush resistance) of at least 500 psi.

**[0030]** The most preferred epoxy resins are solid bisphenol A and solid bisphenol F including liquid epoxy resin. One such epoxy resin is sold as DGEBPA resin by The Peninsula Polymer Company.

**[0031]** The most preferred elastomer is acrylonitrile-butadiene rubber which is sold as NIPOL 1312 by The Zeon Company of Kentucky.

**[0032]** A preferred filler is stearic acid treated calcium carbonate sold as WINNOFIL SPT by The Zeneca Company of Massachusetts.

**[0033]** The preferred fumed silica are sold as CAB-0-SIL TS 720 by The Cabot Company if Illinois.

**[0034]** The preferred high strength glass spheres are sold as B38 Glass Bubbles by The 3M Company of Minnesota.

**[0035]** The most preferred curing agent, cure accelerator and blowing agent are sold as Dicyandimine G sold by SKW of Georgia, AMICURE UR (Air Products Company of Pennsylvania) and CELOGEN OT (Uniroyal Company of Connecticut, respectively.

**[0036]** In the most preferred embodiment, the preparatory material (uncured) 36, should have a dough-like consistency. Material 36 can be prepared by conventional techniques such as mixing the various components together.

**[0037]** In the following table, a preferred formulation for resin-based reinforcement/bonding material 36 is set forth. It is to be understood that this formulation is merely preferred and that other formulations may be suitable in a particular application.

TABLE I

| | WT. % |
|---|---|
| Epoxy Resin | 50.45 |
| Acrylonitrile-Butadiene Rubber | 4.33 |
| Calcium Carbonate | 5.81 |
| Carbon Black | 0.13 |
| Fumed Silica | 3.55 |
| High Strength Glass Spheres | 22.40 |
| Curing Agent | 4.33 |
| Accelerator | 1.29 |
| Blowing Agent | 0.71 |

**[0038]** For assembly of reinforced structural member 18, and referring now to Figures 1 and 3 of the drawings, resin-based reinforcement/bonding material 36 is prepared and placed in carrier 33 as previously described. A number of filled reinforcement members 32 may be prepared at one time and stored for future use. It is to be understood that at the point of time when reinforcement member 32 is to be dropped into channel 34, resin-based reinforcement/bonding material 36 is of a high viscosity such that it is retained within reinforcement

member 32, but it is still capable of expanding and fully curing or solidifying to form a rigid structure (resin body 58) in channel 34 in combination with carrier 33. Bores are drilled through sidewalls 24 and 26 and pin 30 is inserted therein. It will be appreciated that the function of pin 30 is to retain reinforcement member 32 in place in channel 34 and that other securing means such as nubs or the like extending only partially from each opposed sidewall 24 and 26 may be suitable or desirable in any given application. Other retaining means may also be suitable. Preferably, pin 30 is welded in place such that it extends across channel 34 as best shown in Figure 5 and provides strength to structure 18.

**[0039]** Reinforcement member 32 is dropped into channel 34 such that pin 30 slides into slot 60 thereby securing reinforcement member 32 in place (i.e. reinforcement member 32 is restrained from movement longitudinally along channel 34). In the embodiment shown in Figure 1, top plate 22 is then placed on hollow structural member 20 and welded in place such that channel 34 is completely closed. As the motor vehicle moves through a paint oven, resin-based reinforcement/bonding material 36 thermally expands to form rigid resin body 58 which, as stated, locks reinforcement member 32 in channel 34. In other words, once expanded and fully solidified or cured, reinforcement member 32, resin body 58 and opposed walls 24 and 26 form an integral mass of material that adds significant strength to reinforced structural member 18. Although the time and temperatures may vary considerably depending upon the choice of materials used to form resin-based reinforcement/bonding material 36, with the preferred formulations set forth in the foregoing tables, material 36 should be heated to a high enough temperature, depending upon the amount of accelerator, cure agent, and mass.

**[0040]** Reinforced structure 18 has a number of advantages over prior art structures. By strategic placement of reinforcement member 32 at stress points, metal fatigue and cracking may be reduced without the use of heavy gauge metals to form structural member 20. Thus, it is preferred that carrier 32 occupies less than one-half the volume of structure 20, i.e., of cavity 34. It will be appreciated also that the preferred configuration of carrier 33 results in the formation of a series (three in the preferred w-shaped design) of u-shaped or column-shaped structures that extend between sidewalls 24 and 26. Resistance to compressive forces and torque of pin along an axis through sidewalls 24 and 26 and thus along the length of the columns is significant.

**[0041]** It will be appreciated that carrier 33 acts as a container for resin body 58 which keeps the body 58 from bulging, cracking and spalling, as well as acting as a handling mechanism. This is particularly important where resin body 58 is the primary load bearing unit. In turn, resin body 58 stabilizes carrier 33 such that carrier 33 does not buckle prior to the time resin body 33 acts as a support structure.

**[0042]** While a particular embodiment of this invention is shown and described herein, it will be understood that the invention is not to be limited thereto since many modifications may be made, particularly by those skilled in the art, in light of this disclosure. It is contemplated therefore that the present invention cover any such modifications as does fall within the scope of the claims.

## Claims

1. A reinforced structural member, comprising:

   a structural member (20) defining a space (34),

   a reinforcing member (32) disposed in said space (34), said reinforcing member (32) having a carrier portion (33) and a thermally expanded portion (36), wherein said carrier portion (33) is a carrier for said thermally expanded portion (36) and said thermally expanded portion (36) is bonded to said structural member (20) and to said carrier portion (33), and

   means (30) for retaining said reinforcing member (32) in said structural member (20),

   **characterized in that**
   said carrier portion (33) defines a slot and said retaining means (30) includes a projection attached to said structural member (20) and projecting into said space (34), said projection being at least partially disposed in said slot to retain said reinforcing member (32) in said space (34).

2. A reinforced structural member according to claim 1, **characterized in that** said carrier portion (33) has at least one aperture through which a portion of said thermally expanded portion (36) extends, said extended portion of said thermally expanded portion (36) being bonded to said structural member (20).

3. A reinforced structural member according to claim 1, **characterized in that** said thermally expanded portion (36) is a resin-based material.

4. A reinforced structural member according to claim 1, **characterized in that** said structural member (20) is a metal rail section, said carrier portion (33) has a geometry which defines both a slot and at least one reservoir (52,54), said thermally expanded portion (36) is a resin-based material disposed in said reservoir (52,54), said retaining means (30) is a projection extending into said space (34) and attached to said structural member (20), said projection extending into said slot to retain said structural member (20) in said space (34).

5. A reinforced structural member according to claim 4, **characterized in that** said carrier portion (33) is a W-shaped metal sheet having two reservoir portions (52,54), one of said reservoir portions (52) being disposed on one said of said slot and the other of said reservoir portions (54) being disposed on the other side of said slot, said thermally expanded portion (36) being disposed in both of said reservoirs (52,54).

6. A reinforced structural member according to claim 4, **characterized in that** said W-shaped metal sheet has a longitudinal axis passing through both of said reservoirs (52,54) and a transverse axis perpendicular to said longitudinal axis, and wherein said slot is a channel extending along said transverse axis, said structural member (20) having opposed side walls (24,26), and said W-shaped metal sheet being disposed in said space (34) with said transverse axis extending from one of said opposed side walls (24) to the other of said opposed sidewall (26).

7. A reinforced structural member according to one of claims 1-6, **characterized in that** said structural member (20) comprises:

a steel rail having opposed side walls (24,26) and defining a longitudinal channel (40), said longitudinal channel (34) lying along a longitudinal axis, disposed in said channel (34) said cavity-defining resin supporting reinforcement member (32) formed of metal disposed in said channel (34), said resin supporting reinforcement member (32) having at least one column-shaped structure (52,54) and at least one slot, said column-shaped structure (52,54) having a column axis along the length of the column-shaped structure (52,54), said column axis extending between said opposed side walls (24,26) perpendicular to said longitudinal axis,

said retaining means (30) comprises a pin attached to said steel rail and extending into said slot, and

said thermally expanded portion (36) comprises a resin-based core disposed in a cavity defined by said cavity-defining resin supporting reinforcement member (32), said resin-based core being adhered to said sidewalls (24,26) and to said cavity-defining resin supporting reinforcement member (32).

8. A reinforced structural member according to one of claims 1-4, **characterized in that** said cavity-defining resin supporting reinforcement member (32) has a W-shaped configuration which defines three column-shaped structures.

9. A reinforcement insert for reinforcing a hollow structural member (20) according to claims 1-8, said insert comprising:

a metal carrier portion (33) defining a resin-receiving space (52,54) and a pin (30) receiving slot, and

a resin-based portion (36) disposed in said resin-receiving space (52,54), said resin-based portion (36) being less than fully expanded and less than fully cured.

10. A reinforcement insert according to claim 9, **characterized in that** said metal carrier portion (33) has the shape of a W.

11. A method for reinforcing a structural member according to claims 1-8 comprising the steps of:

forming a metal carrier (33), said metal carrier (33) defining a resin-receiving space (52,54) and a slot,

applying an expandable resin-based material to said carrier (33) at said resin receiving space (52,54),

providing a hollow structural member (20) having a longitudinal cavity (34) and securing a pin (30) to said hollow structural member (20) in said cavity (34),

positioning said metal carrier (33) with said resin-based material thereon in said cavity (34) with said pin (30) passing through said slot, and

expanding said resin-based material to bond said carrier (33) to said structural member (20).

12. A method according to claim 11, wherein said expandable resin-based material is thermally expanded and wherein said expansion step is carried out by heating said structural member (20).

13. A reinforced structural member according to one of claims 1-8 for use as reinforced rail for a motor vehicle, **characterized in that**

said structural member (20) comprises a hollow rail section having opposed sidewalls (24,26) defining a longitudinal channel (34),

said retaining means (30) comprises a pin having one end attached to one of said sidewalls (24) and another end attached to the other of

said sidewalls (26),

said carrier portion (33) comprises a W-shaped metal strip defining two reservoirs (54,56) and a slot,

said thermally expanded portion (36) comprises a thermally expanded resin-based core bonded to said W-shaped metal carrier (33) in said reservoirs (52,56),

said W-shaped metal strip (33) being positioned in said hollow rail section (20) between said opposed sidewall (24,26) and being bonded to said sidewalls (24,26) by said resin-based core (36), and

said pin (30) being positioned in said slot.

14. A reinforced structural member according to claim 13, **characterized in that** said rail has a lower wall (28) connecting said opposed sidewall (24,26) and said W-shaped metal strip (30) has at least one aperture (62) therein through which a portion of said resin-based core (36) extends, said extended portion of said core being bonded to said lower wall (28).

15. A reinforced structural member according to claim 1, **characterized in that** said expanded portion (36) contains epoxy resin, an elastomer, fumed silica, high-strength glass microspheres, a blowing agent and a curing agent.

16. A reinforced structural member according to claim 15, further including a filler and an accelerator.

17. A reinforced structural member according to claims 1-8, reinforced by a composition comprising:

epoxy resin,
an elastomer,
fumed silica,
high-strength glass microspheres,
a blowing agent, and
a curing agent.

18. A reinforced structural member according to claim 17, wherein said elastomer is acrylonitrile-butadiene rubber.

**Patentansprüche**

1. Verstärktes Strukturteil mit:

einem Strukturteil (20), das einen Raum (34) definiert,

einem in dem Raum (34) angeordneten Verstärkungsteil (32), das ein Trägerteil (33) und ein Wärmeausdehnungsteil(36) aufweist, wobei das Trägerteil (33) ein Träger für das Wärmeausdehnungsteil (36) ist und das Wärmeausdehnungsteil (36) mit dem Strukturteil (20) und dem Trägerteil (33) verbunden ist, und

einer Einrichtung (30) zum Zurückhalten des Verstärkungsteils (32) in dem Strukturteil (20),

**dadurch gekennzeichnet, dass**
das Trägerteil (33) eine Nut bildet und die Rückhalteeinrichtung (30) einen Vorsprung aufweist, der an dem Strukturteil (20) befestigt ist und in den Raum (34) hinein vorsteht, wobei der Vorsprung mindestens teilweise in der Nut angeordnet ist, um das Verstärkungsteil (32) in dem Raum (34) zurückzuhalten.

2. Verstärktes Strukturteil nach Anspruch 1, **dadurch gekennzeichnet, dass** das Trägerteil (33) mindestens eine Öffnung aufweist, durch die hindurch ein Abschnitt des Wärmeausdehnungsteils (36) verläuft, wobei der hindurchverlaufende Abschnitt des Wärmeausdehnungsteils (36) mit dem Strukturteil (20) verbunden ist.

3. Verstärktes Strukturteil nach Anspruch 1, **dadurch gekennzeichnet, dass** das Wärmeausdehnungsteil (36) ein Material auf Harz-Basis aufweist.

4. Verstärktes Strukturteil nach Anspruch 1, **dadurch gekennzeichnet, dass** das Strukturteil (20) ein Metallschienenabschnitt ist, das Trägerteil (33) eine Geometrie aufweist, die sowohl eine Nut als auch mindestens ein Reservoir (52,54) bildet, das Wärmeausdehnungsteil (36) ein in dem Reservoir (52,54) angeordnetes Material auf Harz-Basis ist, die Rückhalteeinrichtung (30) ein Vorsprung ist, der sich in den Raum (34) erstreckt und an dem Strukturteil (20) befestigt ist, und der Vorsprung sich in die Nut erstreckt, um das Strukturteil (20) in dem Raum (34) rückzuhalten.

5. Verstärktes Strukturteil nach Anspruch 4, **dadurch gekennzeichnet, dass** das Trägerteil (33) ein W-förmiges Blech mit zwei Reservoir-Abschnitten (52,54) ist, wobei einer der Reservoir-Abschnitte (52) an einer Seite der Nut angeordnet ist und der andere der Reservoir-Abschnitte (54) an der anderen Seite der Nut angeordnet ist, und das Wärmeausdehnungsteil (36) in beiden Reservoirs (52,54) angeordnet ist.

6. Verstärktes Strukturteil nach Anspruch 4, **dadurch gekennzeichnet, dass** das W-förmige Blech eine Längsachse, die durch beide Reservoire (52,54)

verläuft, und eine Querachse hat, die rechtwinklig zu der Längsachse verläuft, wobei die Nut ein Kanal ist, der entlang der Querachse verläuft, das Strukturteil (20) einander gegenüberliegende Seitenwände (24,26) aufweist und das W-förmige Blech in dem Raum (34) derart angeordnet ist, dass seine Querachse von einer der einander gegenüberliegende Seitenwände (24) zu der anderen der einander gegenüberliegenden Seitenwände (26) verläuft.

7. Verstärktes Strukturteil nach einem der Ansprüche 1-6, **dadurch gekennzeichnet, dass** das Strukturteil (20) aufweist:

eine Stahlschiene, die einander gegenüberliegende Seitenwände (24,26) aufweist und einen Längskanal (34) bildet, wobei der Längskanal (34) entlang einer Längsachse liegt, das Metall aufweisende, hohlraumbildende Harzhalte-Verstärkungsteil (32) in dem Kanal (34) angeordnet ist, das Harzhalte-Verstärkungsteil (32) mindestens eine säulenförmige Struktur (52,54) und mindestens eine Nut aufweist, die säulenförmige Struktur (52,54) eine Säulen-Achse hat, die entlang der Länge der säulenförmigen Struktur (52,54) verläuft, und die Säulen-Achse zwischen den einander gegenüberliegenden Seitenwänden (24,26) rechtwinklig zu der Längsachse verläuft,

die Rückhalteeinrichtung (30) einen Stift aufweist, der an der Stahlschiene befestigt ist und sich in die Nut erstreckt, und

das Wärmeausdehnungsteil (36) einen Kern auf Harz-Basis aufweist, der in einem durch das hohlraumbildende Harzhalte-Verstärkungsteil (32) gebildeten Hohlraum angeordnet ist, wobei der auf Harz-Basis ausgebildete Kern an den Seitenwänden (24,26) und an dem hohlraumbildenden Harzhalte-Verstärkungsteil (32) anhaftet.

8. Verstärktes Strukturteil nach einem der Ansprüche 1-4, **dadurch gekennzeichnet, dass** das hohlraumbildende Harzhalte-Verstärkungsteil (32) eine W-förmige Konfiguration aufweist, die drei säulenförmige Strukturen bildet.

9. Verstärkungs-Einsatz zum Verstärken eines hohlen Strukturteils (20) gemäß einem der Ansprüche 1-8, mit:

einem Metall-Trägerteil (33), das einen Harzaufnahme-Raum (52,54) und eine Nut zur Aufnahme eines Stifts (30) bildet, und
einem in dem Harzaufnahme-Raum (52,54) angeordneten Teil (36) auf Harz-Basis, das sich in einem nicht voll ausgedehnten und nicht voll gehärteten Zustand befindet.

10. Verstärkungs-Einsatz nach Anspruch 9, **dadurch gekennzeichnet, dass** das Metall-Trägerteil (33) W-förmig ausgebildet ist.

11. Verfahren zum Verstärken eines Strukturteils nach einem der Ansprüche 1-8, mit den folgenden Schritten:

Ausbilden eines Metall-Trägers (33), wobei der Metall-Träger (33) einen Harzaufnahme-Raum (52,54) und eine Nut bildet,

Versehen des Trägers (33) an dessen Harzaufnahme-Raum (52,54) mit einem auf Harz-Basis ausgebildeten ausdehnbaren Material,

Bereitstellen eines hohlen Strukturteils (20) mit einem länglichen Hohlraum (34) und Befestigen eines Stifts (30) an dem hohlen Strukturteil (20) in dessen Hohlraum (34),

Positionieren des mit dem auf Harz-Basis ausgebildeten Material versehene Metall-Trägers (33) in dem Hohlraum (34) bei durch die Nut verlaufendem Stift (30), und

Aufdehnen des auf Harz-Basis ausgebildeten Materials zur Verbondung des Trägers (33) mit dem Strukturteil (20).

12. Verfahren nach Anspruch 11, bei dem das auf Harz-Basis ausgebildete ausdehnbare Material thermisch ausgedehnt wird und bei dem der Ausdehnungsschritt durch Erwärmen des Strukturteils (20) ausgeführt wird.

13. Verstärktes Strukturteil nach einem der Ansprüche 1-8 zur Verwendung als verstärkte Schiene für ein Kraftfahrzeug, **dadurch gekennzeichnet, dass**

das Strukturteil (20) einen hohlen Schienenabschnitt mit einander gegenüberliegenden Seitenwänden (24,26) aufweist, der einen längsverlaufenden Kanal (34) bildet,

die Rückhalteeinrichtung (30) einen Stift aufweist, der mit einem Ende an einer der Seitenwände (24) befestigt und mit dem anderen Ende an der anderen der Seitenwände (26) befestigt ist,

das Trägerteil (33) ein W-förmiges Blech aufweist, das zwei Reservoire (52,54) und eine Nut bildet,

das Wärmeausdehnungsteil (36) einen thermisch ausgedehnten Kern auf Harz-Basis aufweist, der mit dem W-förmigen Metall-Träger (33) in den Reservoiren (52,54) verbunden ist,

der W-förmige Metallstreifen (33) in dem hohlen Schienenabschnitt (20) zwischen den einander gegenüberliegenden Seitenwänden (24,26) positioniert ist und durch den auf Harz-Basis ausgebildeten Kern (36) mit den Seitenwänden (24,26) verbunden ist, und

der Stift (30) in der Nut positioniert ist.

14. Verstärktes Strukturteil nach Anspruch 13, **dadurch gekennzeichnet, dass** die Schiene eine untere Wand (28) aufweist, welche die einander gegenüberliegenden Seitenwände (24,26) miteinander verbindet, und der W-förmige Metallstreifen (33) mindestens eine Öffnung (62) aufweist, durch die hindurch ein Teil des auf Harz-Basis ausgebildeten Kerns (36) verläuft, wobei der hindurchverlaufende Teil des Kerns mit der unteren Wand (28) verbunden ist.

15. Verstärktes Strukturteil nach Anspruch 1, **dadurch gekennzeichnet, dass** das ausgedehnte Teil (36) Epoxyharz, ein Elastomer, Quarzstaub, hochfeste Glas-Mikrokügelchen, ein Treibmittel und ein Härtungsmittel enthält.

16. Verstärktes Strukturteil nach Anspruch 15, ferner mit einem Füllstoff und einem Beschleuniger.

17. Verstärktes Strukturteil nach einem der Ansprüche 1-8, das verstärkt ist durch eine Zusammensetzung, die aufweist:

    Epoxyharz,
    ein Elastomer,
    Quarzstaub,
    hochfeste Glas-Mikrokügelchen,
    ein Treibmittel und
    ein Härtungsmittel.

18. Verstärktes Strukturteil nach Anspruch 17, bei dem das Elastomer Acrylnitril-Butadien-Kautschuk ist.

**Revendications**

1. Un élément structurel renforcé comprenant :

   un élément structurel (20) définissant un espace (34),

   un élément de renfort (32) disposé dans ledit espace (34), ledit élément de renfort (32) ayant une partie support (33) et une partie expansée thermiquement (36) dans laquelle ladite partie support (33) est un support pour ladite partie expansée thermiquement (36) et ladite partie expansée thermiquement (36) est liée audit élément structurel (20) et à ladite partie support (33), et

   un moyen (30) de retenue dudit élément de renfort (32) dans ledit élément structurel (20),

   **caractérisé par le fait que**
   ladite partie support (33) définit une fente et ledit moyen de retenue (30) inclut une saillie attachée audit élément structurel (20) et faisant saillie dans ledit espace (34), ladite saillie étant au moins partiellement disposée dans ladite fente pour retenir ledit élément de renfort (32) dans ledit espace (34).

2. Un élément structurel renforcé selon la revendication 1, **caractérisé par le fait que** ladite partie support (33) a au moins une ouverture par laquelle une partie de ladite partie expansée thermiquement (36) se prolonge, ladite partie prolongée de ladite partie expansée thermiquement (36) étant liée audit élément structurel (20).

3. Un élément structurel renforcé selon la revendication 1, **caractérisé par le fait que** ladite partie expansée thermiquement (36) est un matériau à base de résine.

4. Un élément structurel renforcé selon la revendication 1, **caractérisé par le fait que** ledit élément structurel (20) est une section de rail métallique, ladite partie support (33) a une géométrie qui définit à la fois une fente et au moins un réservoir (52, 54), ladite partie expansée thermiquement (36) est un matériau à base de résine disposé dans ledit réservoir (52, 54), ledit moyen de retenue (30) est une saillie se prolongeant dans ledit espace (34) et rattachée audit élément structurel (20), ladite saillie s'étendant dans ladite fente pour retenir ledit élément structurel (20) dans ledit espace (34).

5. Un élément structurel renforcé selon la revendication 4, **caractérisé par le fait que** ladite partie support (33) est une tôle métallique en forme de W possédant deux parties réservoirs (52, 54), l'une desdites parties réservoir (52) étant disposée d'un côté de ladite fente et l'autre desdites parties réservoirs (54) étant disposée de l'autre côté de ladite fente, ladite partie expansée thermiquement (36) étant disposée dans les deux parties réservoir dites (52, 54).

6. Un élément structurel renforcé selon la revendication 4, **caractérisé par le fait que** ladite tôle métal-

lique en forme de W a un axe longitudinal passant par les deux réservoirs (52, 54) et un axe transversal perpendiculaire audit axe longitudinal et dans lequel ladite fente est un canal s'étendant le long dudit axe transversal, ledit élément structurel (20) ayant des parois latérales opposées (24, 26) et ladite tôle métallique en forme de W étant disposée dans ledit espace (34) avec ledit axe transversal se prolongeant de l'une desdites parois latérales opposées (24) à l'autre desdites parois latérales opposées (26).

7. Un élément structurel renforcé selon l'une des revendications 1-6, **caractérisé par le fait que** ledit élément structurel (20) comporte :

un rail en acier ayant des parois latérales opposées (24, 26) et définissant un canal longitudinal (40), ledit canal longitudinal (34) se trouvant le long d'un axe longitudinal, disposé dans ledit canal (34), ledit élément de renfort supportant la résine et définissant la cavité (32) formé de métal disposé dans ledit canal (34), ledit élément de renfort supportant la résine (32) ayant au moins une structure en forme de colonne (52, 54) et au moins une fente, ladite structure en forme de colonne (52, 54) ayant un axe de colonne le long de la longueur de la structure en forme de colonne (52, 54), ledit axe de colonne se prolongeant entre lesdites parois latérales opposées (24, 26) perpendiculairement audit axe longitudinal,

ledit moyen de retenue (30) comprend une broche attachée audit rail en acier et se prolongeant dans ladite fente, et

ladite partie expansée thermiquement (36) comprend un coeur à base de résine disposé dans une cavité définie par ledit élément de renfort supportant la résine et définissant la cavité (32), ledit coeur à base de résine étant adhérent aux dites parois latérales (24, 26) et audit élément de renfort supportant la résine et définissant la cavité (32).

8. Un élément structurel renforcé selon l'une des revendications 1-4, **caractérisé par le fait que** ledit élément de renfort supportant la résine et définissant la cavité (32) a une configuration en forme de W qui définit trois structures en forme de colonne.

9. Une insertion de renfort pour renforcer un élément structurel creux (20) selon les revendications 1-8, ladite insertion comportant :

une partie support en métal. (33) définissant un espace de réception de la résine (52, 54) et une fente de réception d'une broche (30), et

une partie à base de résine (36) disposée dans ledit espace de réception de la résine (52, 54), ladite partie à base de résine (36) n'étant pas complètement dilatée ni complètement réticulée.

10. Une insertion de renfort selon la revendication 9, **caractérisée par le fait que** ladite partie métallique de support (33) a la forme d'un W.

11. Un procédé de renforcement d'un élément structurel conforme aux revendications 1-8 comportant les étapes suivantes :

formation d'un support métallique (33), ledit support métallique (33) définissant un espace de réception de la résine (52, 54) et une fente,

application d'un matériau expansable à base de résine audit support (33) à l'endroit dudit espace de réception de la résine (52, 54),

mise en oeuvre d'un élément structurel creux (20) ayant une cavité longitudinale (34) et fixation d'une broche (30) audit élément structurel creux (20) dans ladite cavité (34),

positionnement dans ladite cavité (34) dudit support métallique (33) sur lequel est présent le matériau à base de résine, ladite broche (30) passant au travers de ladite fente, et

expansion dudit matériau à base de résine pour lier ledit support (33) audit élément structurel (20).

12. Un procédé selon la revendication 11, dans lequel ledit matériau à base de résine expansée est expansé thermiquement et dans lequel ladite étape d'expansion est réalisée en chauffant ledit élément structurel (20).

13. Un élément structurel renforcé selon l'une des revendications 1-8 pour une utilisation comme rail renforcé pour un véhicule à moteur, **caractérisé par le fait que**

ledit élément structurel (20) est composé d'une section de rail creuse ayant des parois latérales opposées (24, 26) définissant un canal longitudinal (34),

ledit moyen de retenue (30) est constitué d'une broche ayant une extrémité attachée à l'une desdites parois latérales (24) et une autre extrémité attachée à l'autre desdites parois laté-

rales (26),

ladite partie support (33) est constituée d'une tôle en bande en forme de W définissant deux réservoirs (54, 56) et une fente,

ladite partie expansée thermiquement (36) est constituée d'un coeur à base de résine expansée thermiquement lié audit support métallique en forme de W (33) dans lesdits réservoirs (52, 56),

ladite tôle en bande en forme de W (33) étant positionnée dans ladite section de rail creux (20) entre lesdites parois latérales opposées (24, 26) et étant liée auxdites parois latérales (24, 26) par ledit coeur à base de résine (36), et

ladite broche (30) étant positionnée dans ladite fente.

14. Un élément structurel renforcé selon la revendication 13, **caractérisé par le fait que** ledit rail a une paroi inférieure (28) raccordant lesdites parois latérales opposées (24, 26) et ladite tôle en bande en forme de W (30) a au moins une ouverture (62) à l'intérieur de laquelle une partie dudit coeur à base de résine (36) se prolonge, ladite partie prolongée dudit coeur étant liée à ladite paroi inférieure (28).

15. Un élément structurelrenforcé selon la revendication 1 **caractérisé par le fait que** ladite partie expansée (36) contient de la résine époxyde, un élastomère, de la silice fumée, des microsphères de verre à haute résistance, un agent d'expansion et un agent de cuisson.

16. Un élément structurel renforcé selon la revendication 15, incluant en outre une charge et un accélérateur.

17. Un élément structurel renforcé selon les revendications 1-8, renforcé par une composition comprenant :

de la résine époxyde,
un élastomère,
de la silice de calcination,
de microsphères en verre à haute résistance,
un agent d'expansion, et
un agent de réticulation.

18. Un élément structurel renforcé selon la revendication 17, dans lequel ledit élastomère est du caoutchouc acrylonitrile-butadiène.

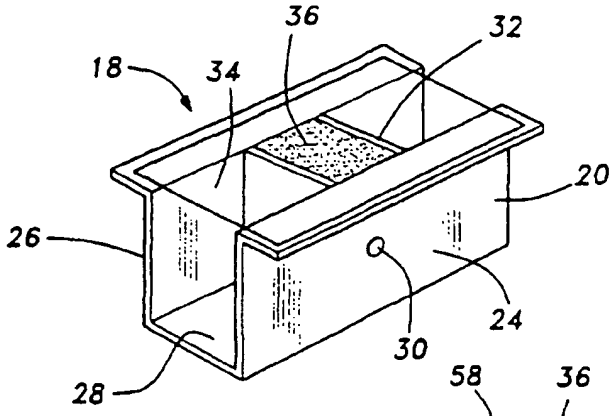


Fig-1

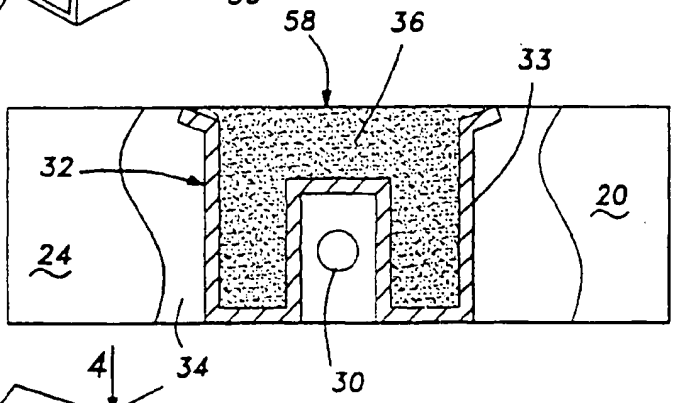


Fig-2

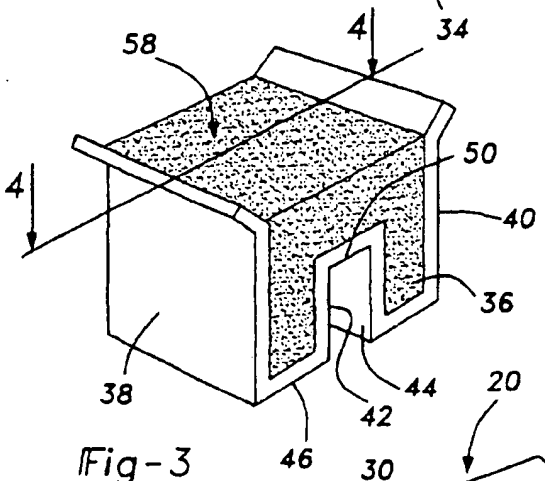


Fig-3

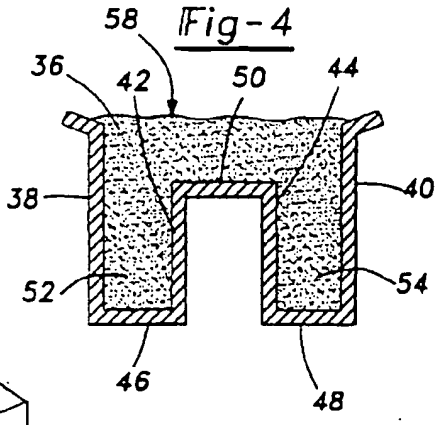


Fig-4

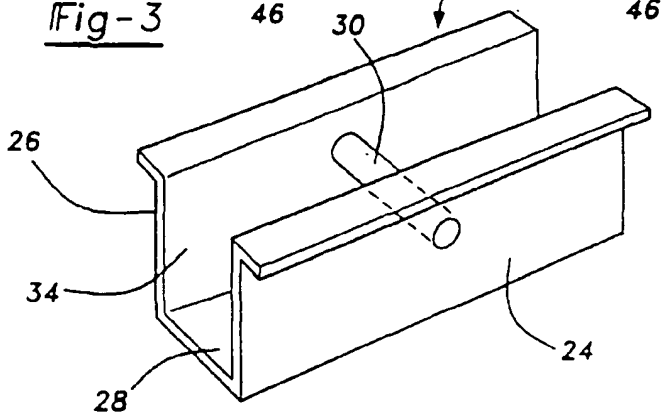


Fig-5

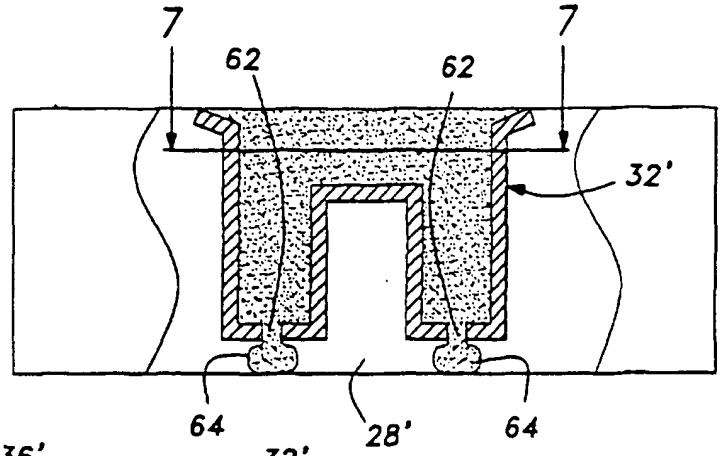


Fig-6

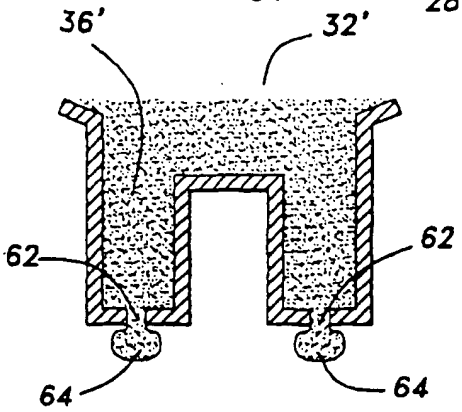


Fig-7

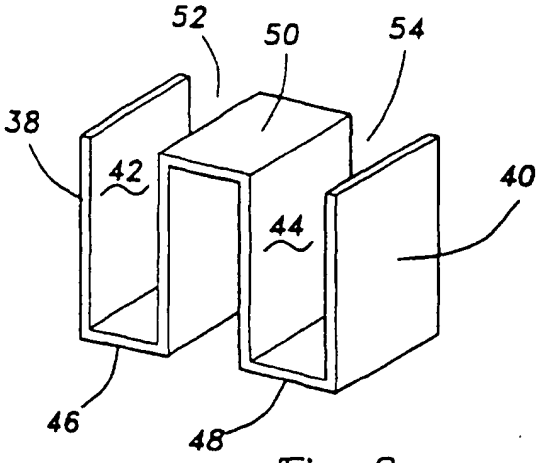


Fig-8

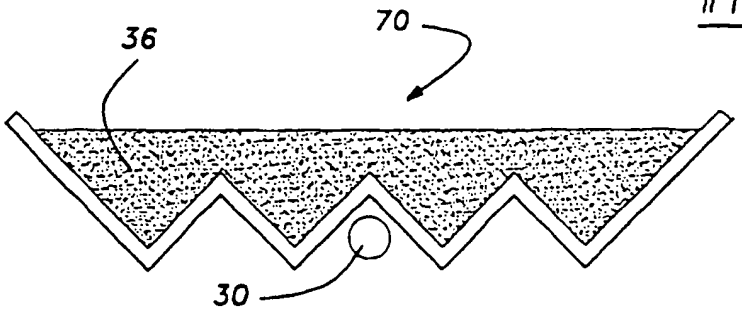


Fig-9

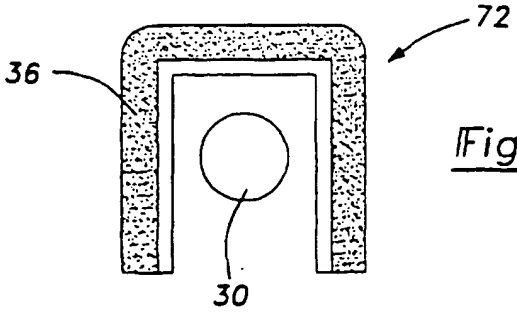


Fig-10

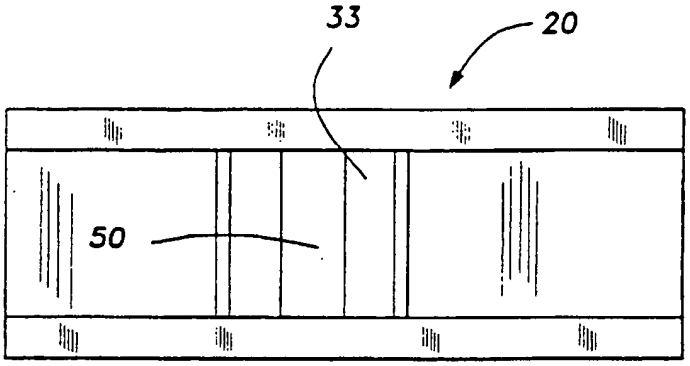


Fig-11

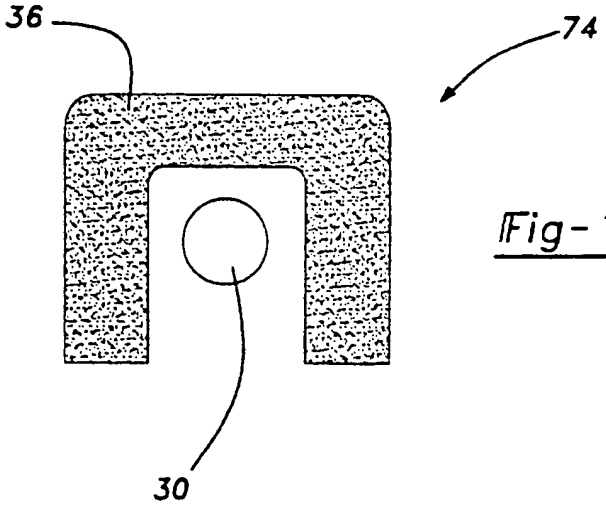


Fig-12